

Claims:

1. A method of continuously punching an array of closely-spaced holes in a deformable strip in a rotary punch which comprises feeding said deformable strip between a female rotary die having a cylindrical periphery with a plurality of spaced recesses formed on the cylindrical periphery and a male/female rotary die having a cylindrical periphery with a plurality of alternating spaced punches and recesses formed on the cylindrical periphery for mating of punches of the male/female rotary die with corresponding recesses of the female die, rotating said female and male/female dies concurrently for punching a first set of spaced holes in the deformable strip along the deformable strip, feeding said punched deformable strip between said male/female rotary die and a male rotary die having a cylindrical periphery with a plurality of spaced punches formed on the cylindrical perimeter for mating of punches of the male rotary die with corresponding recesses of the male/female rotary die, and rotating said male/female die concurrently with the male die for punching a second set of holes in the strip between the first set of spaced holes along the deformable strip.
2. A method as claimed in claim 1, continuously ejecting punched material from the female rotary die and the male/female rotary die.
3. A method as claimed in claim 2, in which the recesses formed on the female rotary die, the alternating punches and recesses formed on the male/female rotary die, and the punches formed on the male die are variably spaced along the strip and/or across the strip, or staggered across the strip.
4. A method as claimed in claim 2, in which the recesses formed on the female rotary die, the alternating punches and recesses formed on the male/female rotary die, and the punches formed on the male die are equispaced.
5. A method of continuously punching an array of closely-spaced holes in a deformable strip in a rotary punch which comprises feeding said deformable strip between a female rotary die having a cylindrical periphery with a plurality of spaced recesses formed on the cylindrical periphery and a male/female rotary die having a cylindrical periphery with a plurality of alternating spaced punches and recesses formed on the cylindrical periphery for mating of punches of the male/female rotary die with

corresponding recesses of the female die, rotating said female and male/female dies concurrently for punching a first set of spaced holes in the deformable strip transversely of the deformable strip along the deformable strip, feeding said punched deformable strip between said male/female rotary die and a male rotary die having a cylindrical periphery with a plurality of spaced punches formed on the cylindrical perimeter for mating of punches of the male rotary die with corresponding recesses of the male/female rotary die, and rotating said male/female die concurrently with the male die for punching a second set of holes in the strip transversely of the deformable strip between the first set of spaced holes along the deformable strip.

5 10 6. A method as claimed in claim 5, continuously ejecting punched material from the female rotary die and the male/female rotary die.

7. A method as claimed in claim 6, in which the recesses formed on the female rotary die, the alternating punches and recesses formed on the male/female rotary die, and the punches formed on the male die are variably spaced along the strip and/or

15 15 across the strip, or staggered across the strip.

8. A method as claimed in claim 5, in which the recesses formed on the female rotary die, the alternating punches and recesses on the male/female rotary die, and the punches on the male die are equispaced.

9. A method as claimed in claim 5, mounting a plurality of angular segments

20 20 continuously about an annulus formed in each of the cylindrical female die and the cylindrical male/female die in proximity to the perimeter of the respective cylindrical dies, each angular segment having at least one ejector pin for radial reciprocal travel in a die recess, and moving the angular segments radially outwardly at a selected angle of rotation of the cylindrical female die and of the cylindrical male/female die for ejecting

25 25 punch-out material from the die recesses.

10. A method as claimed in claim 9, providing a plurality of cam rollers extending loosely across each of the cylindrical female die and the cylindrical male/female die, each cam roller passing through an angular segment for moving said angular segment radially inwardly and outwardly in the die annulus for reciprocal radial movement of a

die ejector pin in a die recess, and moving the cam rollers and associated angular segments outwardly at a selected angle of rotation of each of the dies whereby the angular segment ejector pins eject punch-out material from the cylindrical dies at the selected angles of rotation.

- 5 11. A method as claimed in claim 10, mounting opposite ends of the cam rollers in opposed stationary cam raceways formed on each side of each cylindrical die for controllably moving the cam rollers radially inwardly and outwardly as the dies rotate.
- 10 12. A method as claimed in claim 11, in which the recesses formed on the female rotary die, the alternating punches and recesses formed on the male/female rotary die, and the punches formed on the male die are variably spaced along the strip and/or across the strip, or staggered across the strip.
13. A method as claimed in claim 11, in which the recess formed on the female rotary die and on the male/female rotary die are equispaced.
14. A method as claimed in claim 9, in which the deformable strip is selected from the group of strips consisting of lead, lead alloys, aluminum, brass, copper, steel, zinc, plastics, vinyl and cardboard.
- 15 15. A method as claimed in claim 9, in which the deformable strip is lead or lead alloy.
- 20 16. A deformable strip having an array of closely-spaced holes for manufacturing battery plates produced by the method of claim 15, in which the strip has a plurality of longitudinally-spaced transverse rows of punched holes representing up to about 96% material removed with a residual wire thickness as thin as 0.010 inch.
- 25 17. A lead acid battery having a plurality of battery plates from the strip produced by the method of claim 16, in which the strip has a plurality of longitudinally-spaced transverse rows of punched holes representing up to about 96% material removed with a residual wire thickness as thin as 0.010 inch.
18. An apparatus for continuously rotary punching an array of closely-spaced holes in a deformable strip comprising a cylindrical female die having a plurality of spaced

recesses formed about its periphery and mounted for rotation in a frame, a cylindrical male/female die having a plurality of alternating spaced punches and recesses formed about its periphery and mounted for rotation in said frame for mating the punches of the male/female die with corresponding recesses in the female die, and a cylindrical male

5 die having a plurality of spaced punches formed about its periphery mounted for rotation in said frame for mating of the punches of the male die with corresponding recesses in the male/female die, whereby interaction of the punches of the male/female die with corresponding recesses of the female die and interaction of the punches of the male die with the recesses of the male/female die index the strip with the female,

10 male/female and male dies during rotation.

19. An apparatus as claimed in claim 18, in which said apparatus additionally comprises means for continuously ejecting punch-out material from the female die and from the male/female die during rotary punching of the deformable strip.

20. An apparatus as claimed in claim 19, in which each of the punches in the male/female die has a shoulder formed on each side of the punch for supporting the deformable material and defining the recesses for mating with the punches in the male die.

21. An apparatus as claimed in claim 20, in which the means for continuously ejecting punch-out material comprises a plurality of angular segments mounted in an annulus formed in proximity to the perimeter of the dies continuously about the perimeter of the dies adapted for controlled radial travel of the angular segments during rotation of the dies, each angular segment having at least one ejector pin for radial reciprocal travel in a die recess, whereby outward radial travel of the pin ejects punch-out material from the recess.

25 22. An apparatus as claimed in claim 21, in which each die has a plurality of spaced cam rollers extending loosely across the die in the annulus in proximity to the die perimeter, each cam roller passing through an angular segment for moving said angular cam segment radially inwardly and outwardly in the die, and a pair of opposed stationary cam raceways mounted in the frame at each side of the die for receiving

opposite ends of the cam rollers for controllably moving the cam rollers radially inwardly and outwardly as the die rotates.

23. An apparatus as claimed in claim 20, in which said cylindrical female die comprises a plurality of discs assembled side-by-side, each disc having a plurality of the spaced recesses formed about its periphery in lateral alignment across the die, said cylindrical male/female die comprises a plurality of discs assembled side-by-side, each disc having a plurality of the alternating spaced punches and recesses formed about its periphery in lateral alignment across the male/female die for mating of the punches of the male/female die in lateral alignment across the male/female die with corresponding recesses in the female die in lateral alignment across the female die, and said cylindrical male die comprises a plurality of discs assembled side-by-side, each disc having a plurality of the spaced punches formed about its periphery in lateral alignment across the male die for mating of the punches of the male die with the corresponding recesses in the male/female die in lateral alignment across the male/female die.
- 10 24. An apparatus as claimed in claim 23, in which the spaced recesses formed on the female die, the alternating punches and recesses formed on the male/female and the male die, and the punches formed on the male die are variably spaced about the periphery of each of said dies.
- 15 25. An apparatus as claimed in claim 23, in which the spaced recesses formed on the female die, the alternating punches and recesses formed on the male/female and the male die, and the punches formed on the male die are equispaced about the periphery of each of said dies.
- 20 26. An apparatus as claimed in claim 23, in which the recesses formed in the female die, the punches and recesses formed on the male/female die and the punches formed on the male die are variably spaced and in lateral alignment across the dies.
- 25 27. An apparatus as claimed in claim 23, in which the recesses formed in the female die, the punches and recesses formed on the male/female die and the punches formed on the male die are equispaced and in lateral alignment across the dies.

28. An apparatus as claimed in claim 23, in which the spaced recesses in the female die, the alternating punches and recesses formed on the male/female die and the punches formed on the male die are variably spaced about the periphery of the dies and in lateral alignment across the dies.

5 29. An apparatus as claimed in claim 23, in which the spaced recesses in the female die, the alternating punches and recesses formed on the male/female die and the punches formed on the male die are equispaced about the periphery of the dies and in lateral alignment across the dies.

10 30. An apparatus as claimed in claim 23, in which in which the spaced recesses in the female die, the alternating punches and recesses formed on the male/female die and the punches formed on the male die are variably spaced about the periphery of the dies and staggered across the dies.

15 31. An apparatus as claimed in claim 23, in which in which the spaced recesses in the female die, the alternating punches and recesses formed on the male/female die and the punches formed on the male die are equispaced about the periphery of the dies and staggered across the dies.

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